Hydropower Investment Promotion Project (HIPP)

TRANSMISSION ASSESSMENT

Georgian and Turkish Grid Capability to Accommodate Georgian Export and Azerbaijan Wheel to Load Centers in Turkey

DECEMBER, 2010

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GEORGIAN AND TURKISH GRID CAPABILITIES TO ACCOMMODATE GEORGIAN EXPORT AND AZERBAIJAN WHEEL TO LOAD CENTERS IN TURKEY

USAID HYDROPOWER INVESTMENT PROMOTION PROJECT (HIPP)

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DELOITTE CONSULTING LLP

IN COLLABORATION WITH BLACK & VEATCH AND PIERCE ATWOOD ATTORNEYS LLC.

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ASSESSMENT OF GEORGIAN AND TURKISH GRIDS

1.0 Conclusions

The nature of the HVDC back to back converter facilitates the transfer of power between Georgia and Turkey by eliminating many of the issues associated with interconnecting two power systems with a relatively weak tie or systems with incongruous operating conditions. The asynchronous nature of the HVDC back to back converter provides a decoupling between the two systems that allows each interconnected system to develop more or less independent of the other provided each is able to deal with the power flow to and from the HVDC back to back converter and any sudden shutdown of the converter. In the particular case of power exports from Georgia to Turkey, the Georgian system must be capable of reliably delivering power from electric generators to the HVDC back to back converter and the Turkish system must be able to move the power from the HVDC converter to the loads.

The planned additions to the Georgian 500 kV grid and the reinforcements to the underlying 220 kV will provide for the reliable transfer of power along the 500 kV backbone to the planned Akhaltsikhe substation at the levels currently planned for the converter (Stage 2 - 700 MW). Addition of the Zekan and Vardzia lines provide a redundant path between generation in the north and central part of the country to the planned Akhaltsikhe substation. GSE studies have confirmed the transfer capabilities for the network. However GSE studies have also noted that loss of the planned 500 kV line between Zestaponi and Alkahaltsikhe (Zekan) may require curtailment of the Turkish export of because generation in the north and west of Georgia would have to travel approximately 400 km from Zestaponi to Gardabani to Alkhaltsikhe. This potential limitation must be further investigated.

The wheel of power from Azerbaijan through Georgia to Turkey represents counter flow in the east to west direction on the Georgian grid which is in opposition to the west to east flow under normal conditions. The Georgian grid will be capable of wheeling this energy to Turkey, subject to the capacity of the HVDC back to back converter and the interconnecting 400 kV line to Turkey. The planned additions to the Georgian 500 kV grid also serve to provide redundant paths within Georgia for delivery of the Azerbaijan power to the HVDC back to back converter. Unlike the curtailment potential for power generated in the north and west, loss of one of the three lines forming the redundant path would have minimal impact on the wheel from Azerbaijan.

The capability of the Turkish grid is less certain but will be better quantified following completion of the joint study by GSE and TEIAS. In the interim, Georgia and Turkey have agreed in a Memorandum of Understanding sign between the Ministry of Energy and Natural Resources of Turkey and the Ministry of Energy of Georgia signed on July 29, 2009 to *support the technical operators of Georgia and Turkey (GSE, TEIAS) for the construction of new 400 kV electric transmission line (Akhaltsikhe-Borcka) which will have 1000 MW capacity. The net energy transfer by the transmission line in 2012 will be up to 650 MW and it will be increased to 1000 MW in the future in accordance with the development of the power demand of both countries.*

The information and conclusions in this report were made based on large part from discussions with GSE and TEIAS staff. Documented results from relevant transmission studies were not always available to validate conclusions. Certain published studies of the Georgian grid are available but they are not recent and the planned Georgian grid has evolved since these studies were first conducted. Future analysis of the viability of the Georgian and Turkish grids to support the export of power from Georgia and the wheel of power between Azerbaijan and Turkey through Georgia should be based on updated documented studies. GSE and TEIAS have begun a joint study to address transfer capability from HPP in Georgia to load centers in Turkey and the results from this study should resolve many of the potential issues raised in previous studies.

2.0 Background

Georgia is a net exporter of electricity with current public and private investments promoting HPP expansion. The increasing awareness of the benefits of "green" energy meshes well with Georgia's surplus of clean hydro power suitable for development as run of river hydroelectric generation. Load growth in Georgia's neighbors, particularly Turkey, provides an opportunity for Georgia to capitalize on its natural resources by supplying its neighbors with clean and reliable hydroelectric energy.

Georgia ranks as a "Top Country" globally in water resources per capita. These resources are in excess of its current and foreseeable needs. Approximately 300 rivers are significant in terms of energy production with a total potential capacity of 15 GW and an average annual production of 50 GWh. Critical to the effort to expand Georgia's hydroelectric power production is the ability to deliver the electric energy to the load centers in the receiving countries.

Turkey has been identified as the prime recipient for newly developing Georgia hydroelectric power and this assessment focus on the ability of the Georgian and Turkish grids to move the power from locations in Georgia where clusters of hydroelectric generation will interconnect to the Georgian grid and deliver power to load centers in Turkey. The assessment also addresses the potential for surplus electric power in Azerbaijan to be wheeled through Georgia to Turkey. Both hydroelectric power generated in Georgia and wheeled power from Azerbaijan will be delivered to Turkey at a common interconnection point through a HVDC back to back converter and associated 400 kV transmission line.

This assessment looked at the major issues that influence the delivery of power as described, the studies that have or will be conducted to identify any problems, the current status of both the Georgian and Turkish grids, major additions that are being planned, and the assessment of the planned systems to deliver the power. Recommendations on future studies are also provided.

3.0 Major Issues Addressed

Five major issues were addressed in assessing the overall capabilities of the Georgian and Turkish power systems to reliability move power from Georgia to Turkey either from hydroelectric power plants in Georgia or through wheeling power from Azerbajian.

- Adequacy and reliability of Georgian power system to deliver HPP exports to the planned HVDC back to back converter at the Akhaltsikhe substation.
- Adequacy and reliability of the Georgian grid to wheel power from Azerbaijan to the HVDC back to back converter converter at the Akhaltsikhe substation.
- Adequacy and reliability of Turkish power system to accept scheduled interchange from HVDC back to back intertie.
- Increased generating plant construction in Northeast Turkey near the Georgian border.
- Most recent information available related to transmission is from discussions with individuals and represents in some cases their opinions and observations. Relevant documented studies are difficult to find and recommendations for future studies are addressed.

4.0 Supporting Transmission Studies

4.1 Completed Transmission Studies

Information from the following studies was used in assessing the ability of the Georgian power system to reliably transmit internally generated hydroelectric power and to reliably wheel power from Azerbajian to the Akhaltsikhe S/S HVDC back to back converter. Some of the studies also address the transmission through the HVDC converter and on to Borcka S/S in Turkey. None of the completed studies listed below addressed the ability of the Turkish grid to move power from Borcka to load centers in Turkey.

- GSE internal studies
- Feasibility Study for the Georgian High Voltage Transmission Lines Project, Kuljian Corporation, USTDA Grant No. GH068105024, December 2007.
- Regional Power Transmission Extension Plan for Caucasus Countries, Final Report, November 2007, Fichtner Report 4899P40/FICHT-2723977.
- Studies reported in various Black Sea Regional Transmission Planning Project (BSTP) Progress Reports

4.2 Future Transmission Studies

The planning for the expansion of the Georgian grid has become better defined since most of the studies cited above were completed and new or updated studies are being planned to reflect the more recent definition of the Georgian grid expansion.

- Fichtner/KfW plans to update 2007 study.
- GSE internal studies.
- BSTP including participation by GSE
- USAID's New Power and Gas Infrastructure Program (TetraTech and Power Engineers).
- Joint transmission study between GSE and TEIAS to determine transfer capability of Turkish grid from Georgia to Turkish load centers. Draft report due in the summer of 2011.

Of particular importance is the joint transmission study between GSE and TEIAS which is the only study that specifically address the transfer of power from HPP sites in Georgia to load centers in Turkey. Results from this study should provide the most complete assessment of the movement of energy through Georgia to load centers in Turkey. It will also better define the limitations to maximum power transfer capabilities (currently set at 650 MW by the 2007 Memorandum of Understanding between Georgia and Turkey) and define the relative benefits of a second 400 kV line from Akhaltsikhe to a substation in Turkey other than Borcka (e.g. Tortum). The results from this study are scheduled for initial release in the Summer of 2011.

5.0 Georgian grid

5.1 Overview of Georgian grid

The Georgian transmission grid comprises approximately 6,200 kv of high voltage alternating current (HVAC) network operating at 500 kV, 220 kV, 110 kV, and 35 kV. A 500 kV backbone running roughly west to east connects the center of hydroelectric power generation with load centers in the east, principally the Tbilisi area. A 220 kV system of parallel lines underlies the 500 kV system and, coupled with 110 kV lines, provides a convenient voltage for interconnecting moderate and small hydroelectric generation to the grid.

Georgia also is interconnected to its neighbors through existing and planned transmission.

Appendix 1 shows a map of the Georgian grid with major planned additions.

5.2 Interconnections with neighboring countries

Georgia has interconnections with all of its neighbors and is planning additional interconnections in the future.

5.2.1 Interconnection with Russia

Georgia currently has four interconnections with Russia

- A 500 kV interconnection from the Enguri HPP to Russia to accommodate Russia's partial ownership of the Enguri plant.
- A 220 kV line interconnects from the Tkvarchili TPP and Vardnili HPP to Russia
- Two 110 kV lines from isolated HPPs in the Caucasus region

5.2.2 Interconnection with Armenia

Georgia has three current and one planned interconnection with Armenia.

- A 220 kV interconnection from the Gardabani S/S
- A planned 400 kV interconnection from Ksani S/S
- Two 110 kV lines from isolated HPP in southern Georgia

At the present time, the interconnections with Armenia are not in service or are operated to isolated areas in Armenia. Experience has shown that Georgia is not able to operate synchronously with Armenia because of Armenia's interconnection with Iran. The Iranian grid frequency control has a greater allowable range which has caused instability on the Georgian system in the past.

5.2.3 Interconnection with Azerbaijan

Georgia has two interconnections with Azerbaijan.

- A 330 kV interconnection from Gardabani
- A 500 kV interconnection from Gardabani which is currently not functioning.

5.2.4 Interconnection with Turkey

Georgia has one current interconnection and one planned interconnection with Turkey.

- A 220 kV interconnection from the Batumi S/S feeding an isolated area in Turkey. Energo-Pro has plans to install a 350 MW HVDC back to back converter at this interconnection in the future to allow the Turkish side to connect to the Turkish grid.
- A planned 400 kV interconnection through a HVDC back to back converter located at the new Akhaltsikhe S/S.

5.3 Issues with current grid and planned mitigation

A number of issues exist in the current grid have been identified as potential limiting factors in achieving the transfer of energy to Akhaltsikhe S/S.

- The existing 500 kV grid lacks sufficient redundancy to reliability move power within Georgia. The underlying 220 kV system is subject to overload in the event of loss of either the 500 kV Imerti line of the 500 kV Karti II lines. Increased power transfers associated with export to Turkey from Georgian HPP and growing load in the eastern part of the country require reinforcement of the grid.
- The existing Energo-Pro 220 kV line from Bat'umi to Turkey would not support fully anticipated export of 1000 MW and the inability to interconnect with the Turkish grid does not support energy sales in Turkey. Therefore a larger capacity asynchronous interconnection is required. The planned 350 MW HVDC back to back does not have the capacity desired and it does not have the required 500 kV interconnection to the Georgian grid.

5.4 Planned expansion of Georgian grid

The Georgian grid has planned expansion that will improve the transfer capability and overall reliability of the system. The expansion includes the following.

5.4.1 Underlying 220 kV system

The underlying 220 kV system is subject to overload in the event of loss of any of the 500 kV lines. This is due to the lack of redundancy in the 500 kV system which transfers the power flow to the underlying system in case of an outage. Addition of the Zestaponi to Akhaltsikhe to Gardabani 500 kV path provides an alternative 500 kV path in the central and eastern part of the system but the 500 kV line between Enguri and Zestaponi does not currently have a second parallel 500 kV path. Loss of this line will transfer the power flow to the underlying 220 kV system in that region. The 220 kV system does not have the capability to carry the power displaced from the 500 kV system.

The 220 kV system in the area of the Menji S/S is being strengthen to provide a greater transfer capability on the underlying 220 kV system between Enguri and Zestaponi. There is no redundancy planned for the 500 kV between Enguri and Zestaponi and loss of the 500 kV line will require the underlying 220 kV system to be able to carry the load from the 500 kV line (N-1 criteria). A Georgian single 220 kV line is normally rated between 250 MVA and 380 MVA and after the reinforcement, there will be dual 220 kV paths underlying the 500 kV which is sufficient for approximately 33% to 50% of the capacity of the 500 kV line.

The reinforced 220 kV system will also improve capacity and reliability for the Vardnili HPP, Namakhvani HPP and Kutaisi HPP areas and makes them more attractive development sites.

5.4.2 Akhaltsikhe Substation

The existing Energo-Pro 220 kV line from Bat'umi to Turkey would not support fully anticipated export of 1000 MW or more to Turkey. Both the line voltage and the relatively weak interconnections at both the Georgian and Turkish ends of the line are insufficient to accommodate a 1000 MW flow. Addition of a 350 MW HVDC back to back converter on the line would not be sufficient to accommodate the planned expansion of HPP in Georgia. In addition, there is no 500 kV interconnection in that area.

A new 500 kV S/S at Akhaltsikhe is being constructed to accommodate a HVDC back to back converter, a new 400 kV line to Turkey, and new 500 kV lines from Zestaponi and Gardabani. The new substation will be fed by two 500 kV lines to provide redundant feeds for export to Turkey. Each line (rated 1500 MVA) is capable of carrying the capacity of the full buildout of the HVDC converter (1050 MW). This substation provides one corner of a triangle of 500 kV lines providing a central backbone with redundant power transfer across Georgia.

5.4.3 Intertie with Russia

The primary intertie with Russia is via a single 500 kV line. Loss of this line results in a load rejection on the Georgian system which must be accommodated by tripping sufficient generation at Enguri to compensate for the loss of transmission. No alternative path for this flow is available and none is currently planned.

5.4.4 500 kV lines

The current 500 kV backbone through Georgia does not provide sufficient redundancy to meet a N-1 criteria. Severe limiting of power transfer capability occurs when the Karti lines are out of service since the underlying 220 kV system is not able to carry the full capacity of the 500 kV lines. This is true for normal west to east flow which serves load in the eastern part of Georgia but also potentially true for the wheel from Azerbaijan to Turkey. Several 500 kV lines are planned to mitigate this issue.

Two new 500 kV line between Zestaponi and Akhaltsikhe (Zekari line) and Akhaltsikhe and Gardabani (Vardzia), in conjunction with the existing 500 kV line between Zestaponi and Gardabani, form a triangle of 500 kV lines that provide a redundant path across Georgia. Each of these lines has a capacity of approximately 1500 MVA. That path serves three primary functions.

- Flow of power to supply Georgian domestic load in the east from generation in the west
- Flow of power for export to Turkey
- Flow of power for wheel of power from Azerbaijan to Turkey

Additions of these lines forms a triangle of transmission which provides redundancy for the loss of any one of the three lines. However, loss of the line between Zestaponi and Akhaltsikhe will require that power generated in the north and west must travel approximately 400 km from Zestaponi to Gardabani to Akhaltsikhe for export to Turkey. Earlier studies by GSE indicated that it may be necessary to curtail transfer to Turkey to 200 MW under this condition.

5.4.5 Operational issues on the Georgian grid

There have been past issues with inadequate communications and control to trip generation in response to certain disturbances. In addition, there have been unexplained trips of the 500 kV lines for what appeared to be disturbances on the 220 kV system. Recent and planned improvements to the protection and communications are reportedly able to have corrected these issues to prevent unnecessary system outages. A comprehensive review of the grid is being performed by Tetratech and Power Engineers which will address a number of operational issues. USAID Georgia Power Infrastructure Project (PGIP) will be addressing some of these issues.

5.5 Assessment of Georgian Grid after planned improvements

The planned improvements to the Georgian grid will provide a redundant and reliable designed for moving energy to serve domestic load in the east from generation resources in the west. The redundant paths formed by the triangle of lines (Vardzia, Zekari, and Kartii) strengthen the overall path from west to east and relieves the overloads on the underlying 220 kV network in the event of loss of one of the 500 kV lines (N-1 criteria).

The planned improvements provide the same triangle of support for flows from new HPP to support the export of energy to Turkey as well as the wheel of power from Azerbaijan to Turkey through the HVDC back to back converter. This assessment is based on earlier studies (2007 and 2008) performed by GSE and Fichtner which assume specific generation profiles and transmission reinforcements. Update studies are being planned to reflect changes in planned transmission and generation since the original studies were performed. In general, the studies found that static power flow under contingency conditions was adequate and curtailment was not necessary to avoid transmission violations. There are two conditions that have been noted in studies, however, that should be further investigated during the joint Turkey and Georgia transfer studies.

- The Fichtner study noted that addition of a line from Enguri to Akhaltsikhe resolves certain dynamic issues. However, this line is no longer being planned so the dynamic issues noted in the Fichtner study need to be revisited. The Fichtner study is scheduled for updating and this issue may be resolved.
- GSE studies have shown that loss of the line between Zestaponi and Akhaltsikhe may require restriction of the Turkish export to 200 MW. Under this condition, power from generation in the north and west would have to travel down the Karti lines and back along the Vardzia, a distance of approximately 400 km. Clarification of this restriction should be pursued to determine if there are mitigating actions that can be taken.

6.0 Turkish grid

The Turkish transmission grid is a well developed 400 kV network with an underlying network of 154 kV and lower voltages. The system is more strongly interconnected in the west where the major load centers around the Marmara Sea are located and in the central part of the country in the Ankara area and in the south along the Mediterranean. The grid is less well developed in the eastern part of the country where the interconnection with Georgia will be located. A 400 kV line is planned to connect the HVDC back to back converter to the Borcka Substation. A second 400 kV line is under consideration between the HVDC back to back converter and either Artvin or Tortum substations in Turkey.

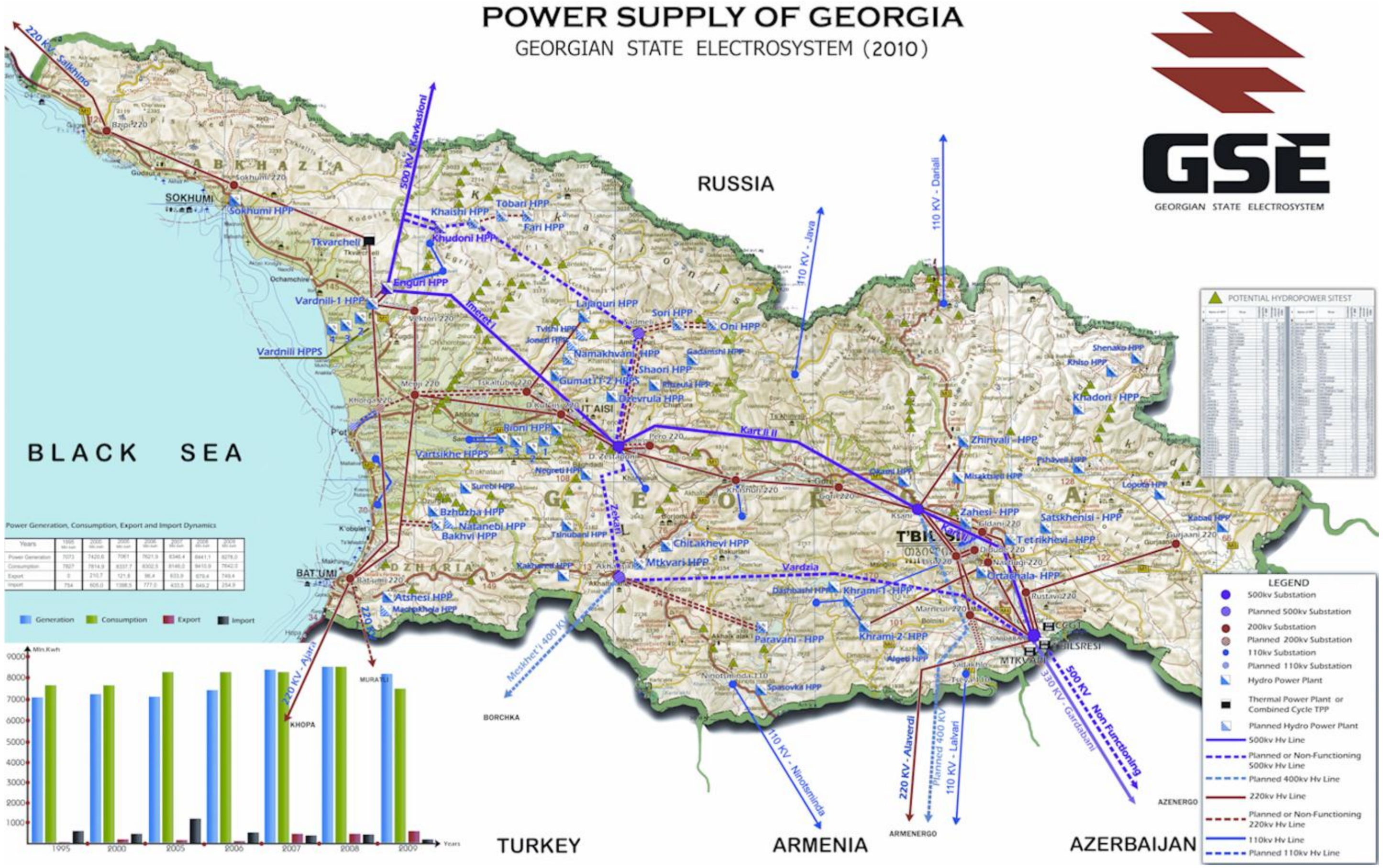
During a discussion with TEIAS engineers Gul Okan and Nurhan Ozan, generation expansion in the northeast part of Turkey and the Georgian import has prompted to a joint study by Georgian State Electrosystem (GSE) and the Turkish Electric Transmission Company (TEIAS) to address the ability of the Turkish grid to move power from the HVDC back to back converter and into load centers in Turkey. This was confirmed by Ucha Uchaneishvili of GSE. According to TEIAS, GSE will study the Georgian portion of the area and TEIAS will study the Turkish portion. The isolating nature of the back to back HVDC converter allows separation of the studies for power flow analysis but dynamic analysis will require use of an integrated model. Initial results from the study are expected in the summer of 2011.

At the current time, transfer on the 400 kV line to Borcka will be restricted to 650 MW through a Memorandum of Understanding between Georgia and Turkey signed on July 29, 2009. The 400 kV line will be rated at 1000 MW and the back to back HVDC converter will be rated at 700 MW initially but is expandable to 1050 MW.

Earlier information indicated that there was minimal load expansion anticipated in the eastern part of Turkey but in discussions with TEIAS, they stated that it was anticipated the load would also grow significantly in the eastern portion as well. If this load growth materializes, it may reduce the need for increasing the transfer capability of the Turkish grid to move power from the east to the west and south.

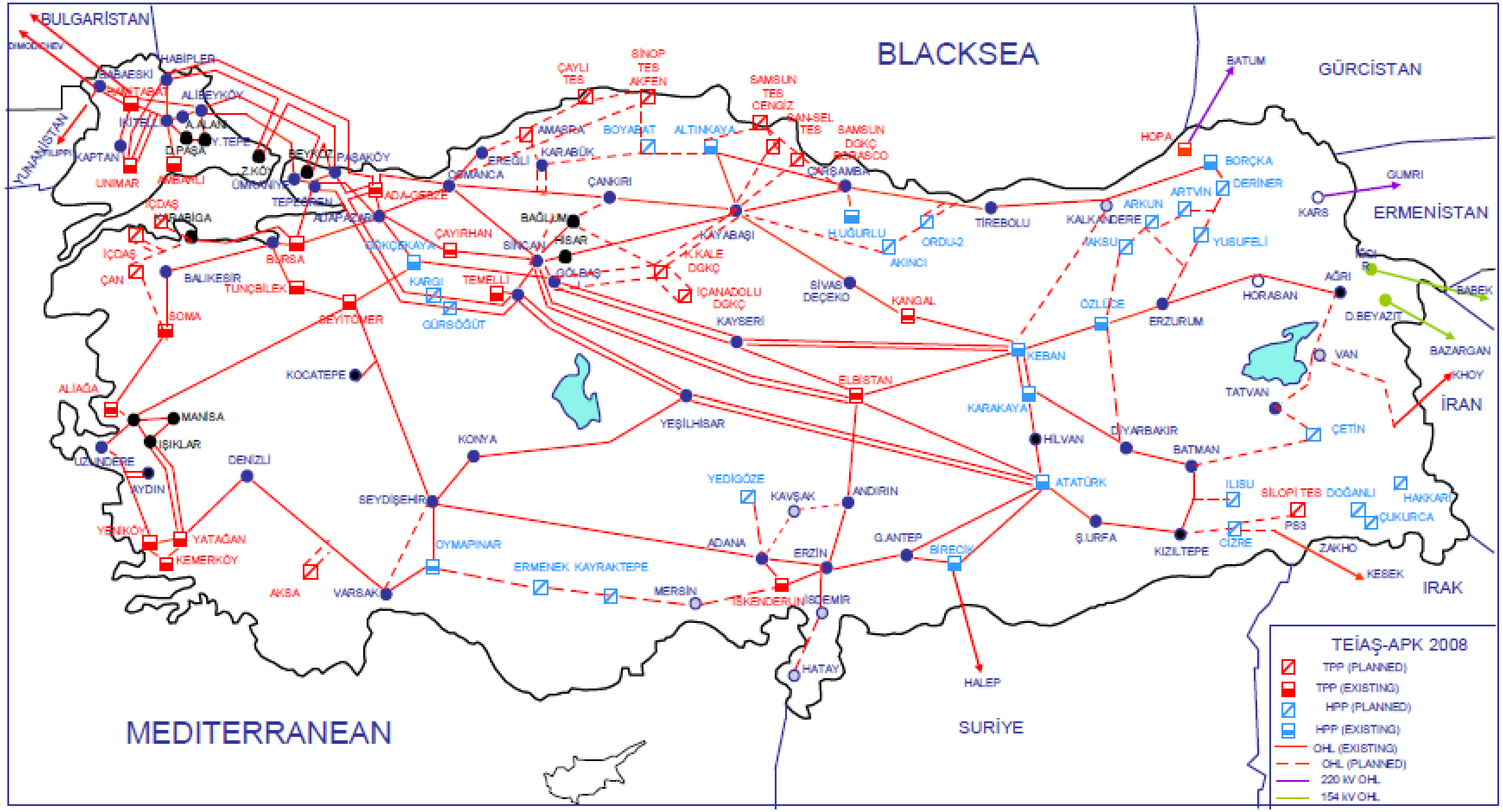
Appendix 2 shows a simplified map of the Turkish grid. Planned generation and transmission additions are listed in the accompanying tables. Most of the transmission additions appear to be dedicated to collecting and delivering new HPP energy to major transmission nodes. It is not clear that these additions represent a planned strengthening of the 400 kV backbone.

Appendix 1


POWER SUPPLY OF GEORGIA
GEORGIAN STATE ELECTROSYSTEM (2010)
GSE
GEORGIAN STATE ELECTROSYSTEM
RUSSIA
BLACK SEA
TURKEY
ARMENIA
AZERBAIJAN
Power Generation, Consumption, Export and Import Dynamics
Generation
Consumption
Export
Import
POTENTIAL HYDROPOWER SITEST
LEGEND
500kv Substation
Planned 500kv Substation
200kv Substation
Planned 200kv Substation
110kv Substation
Planned 110kv Substation
Hydro Power Plant
Thermal Power Plant or Combined Cycle TPP
Planned Hydro Power Plant
500kv Hv Line
Planned or Non-Functioning 500kv Hv Line
Planned 400kv Hv Line
220kv Hv Line
Planned or Non-Functioning 220kv Hv Line
110kv Hv Line
Planned 110kv Hv Line

Appendix 2

Turkish Grid



Planned Turkey Generation Additions

TYPE	SUBSTATION1		VOLTAGE LEVEL kV	VOLTAGE LEVEL kV	CAPACITY MW	CAPACITY MVA	DATE OF COMMISSIONING year	STATUS	COMMENT
1	2	3	4	5	6	7	8	9	10
HPP	TR	Ermenek		400	320		2010	CONSTR	
HPP	TR	OBRUK		400	4x50		2010	CONSTR	
HPP	TR	Borçka		400	300		2010	FINISHED	
HPP	TR	Deriner		400	670		2010	CONSTR	
TPP	TR	TEREN		400	2X600		2015	PLANNED	Coal fired TPP
HPP	TR	TIREB		400	300		2015	PLANNED	Equivalent of lots of HPPs in the river basin, most of them run of river type
HPP	TR	KALKANDERE		400	3X200		2015	PLANNED	Equivalent of lots of HPPs in the river basin, most of them run of river type
HPP	TR	YUSUFELI		400	4x135		2015	PLANNED	Equivalent of lots of HPPs in the river basin, most of them run of river type
CCGT	TR	TBANDRMA		400	1000		2015	PLANNED	NGCCPP(Private company)
CCGT	TR	AMBARLI		400	2X270		2015	PLANNED	NGCCPP. Extension of existing Ambarlı NGCCPP
CCGT	TR	AKSA ANTALIA		400	1000		2015	PLANNED	NGCCPP(Private company)
TPP	TR	SUGOZU		400	700		2015	PLANNED	Coal fired. Extension of existing Sugozu TPP
CCGT	TR	DENIZLI		400	1000		2015	PLANNED	NGCCPP(Private company)
HPP	TR	BOYABAT		400	3X180		2015	PLANNED	HPP(Private company)
TPP	TR	GALATA		400	2X135		2015	PLANNED	TPP (oil fired)
CCGT	TR	MAKINA		400	2X300		2015	PLANNED	NGCCPP(Private company)
HPP	TR	ALKUMRU		400	3X80		2015	PLANNED	HPP(Private company)
CCGT	TR	RASA		400	80		2015	PLANNED	NGCCPP(Private company)
TPP	TR	SILOPITES		150	135		2015	PLANNED	TPP (oil fired)
HPP	TR	INCIR		150	122		2015	PLANNED	HPP(Private company)
HPP	TR	AKDAM		400	300		2015	PLANNED	Equivalent of lots of HPPs in the river basin, most of them run of river type
CCGT	TR	EGEMER		400	6X300		2015	PLANNED	NGCCPP+ Coal fired(Private company)
WPP	TR	GELI		400	300		2015	PLANNED	Equivalent of lots of WPPs in the region
WPP	TR	CAN		400	300		2015	PLANNED	Equivalent of lots of WPPs in the region
TPP	TR	BASAT		400	2X150		2015	PLANNED	Coal fired TPP
TPP	TR	ORTA		400	2X150		2015	PLANNED	Coal fired TPP
TPP	TR	ATLAS		400	600		2015	PLANNED	Coal fired TPP
TPP	TR	KARASU		400	2X600		2015	PLANNED	Coal fired TPP
HPP	TR	ILISU		400	6x200		2015	PLANNED	
NPP	TR	Akkuyu Bay		400	5x1100		2020	PLANNED	

1. Type of plant (HPP - Hydropower plant, TPP - Thermal power plant, PSHPP - Pump Storage Hydro Power Plant, CCHP - Combined Cycle Heating Plant...)
2. Country
3. Substation name
4. Generator voltage level
5. Network voltage level
6. Installed active power
7. Installed apparent power
8. Date of commissioning (estimate)
9. Status of the project (Idea, Feasibility study, Construction...)

Planned Turkey Transmission Additions

TYPE		SUBSTATION1		SUBSTATION2	VOLTAGE LEVEL kV/kV	Number of circuits /units	CAPACITY A or MVA	CAPACITY limited A or MVA	MATERIAL OR TRANSFORMER TYPE	CROSS mm2	LENGTH BR1 km	LENGTH BR2 km	LENGTH TOTAL km	DATE OF COMMISSION	STATUS	COMMENT
1	2	3	2	3	4	5	6	7	8	9	10	11	12	13	14	15
OHL	TR	Hpp oymapinar		Hpp ermenek	400	1			Acsr	3bx1272					Constr	
OHL	TR	Mersin		Hpp ermenek	400	1			Acsr	3bx1272					Constr	
SS	TR	Mersin			400/150		2x250								Constr	
DC	TR	Alibeykoy			400		600 mw								Idea	Dc converter station
SC	TR	Alibeykoy	Ro	Constanta	400	1	600 mw				200	200	400		Idea	Dc cable
OHL	TR	Gercuz-ilisu		Cizre-sinir	400	2			Acsr	3bx954	30	100	130		Planning	Planning
OHL	TR	Agri		Van	400	1			Acsr	3bx1272					Planning	
OHL	TR	Batman-siirt		Van	400	1			Acsr	3bx1272	65	205	270		Planning	
OHL	TR	Van		Baskale	400	1			Acsr	3bx954					Planning	
OHL	TR	Hpp boyabat		Hpp altinkaya	400	1			Acsr	3bx1272					Planning	
OHL	TR	Seydisehir		Varsak	400	1			Acsr	3bx1272			130		Constr	
OHL	TR	Temelli		Afyon2	400	1			Acsr	3bx1272					Constr	
OHL	TR	Afyon2		Denizli	400	1			Acsr	3bx1272			180		Constr	
OHL	TR	Bursa ngccpp		Bursa san	400	2			Acsr	3bx954					Planning	
OHL	TR	Icdas		Bursa san	400	1			Acsr	3bx954					Planning	
OHL	TR	Soma		Manisa	400	1			Acsr	3bx1272			50		Constr	
OHL	TR	Ozluce		Diyarbakir	400	1			Acsr	3bx1272			100		Constr	
SS	TR	Konya			400/150		150								Constr	Capacityadd
SS	TR	Adana			400/150		250								Constr	
SS	TR	Eskisehir			400/150		2x250								Constr	
SS	TR	Catalca			400/150		2x250								Planning	
SS	TR	Kucukbakkalkoy gis			400/150		2x250								Constr	
SS	TR	Kucukbakkalkoy gis			400/33		2x125								Constr	
C	TR	Umraniye		Kucukbakkalkoy	400					2000mm2			6.3		Constr	
SS	TR	Van			400/150		2x250								Planning	
SS	TR	Uzundere			400/33		125								Planning	
SS	TR	Yenibosna gis			400/150		2x250								Constr	
SS	TR	Yenibosna gis			400/33		2x125								Constr	
C	TR	Yenibosna gis		Davutpasa	400					2000mm2			6.98		Constr	
SS	TR	Afyon2			400/150		2x250								Constr	Capacityadd
SS	TR	Viransehir			400/150		250+150								Constr	
SS	TR	Diyarbakir			400/33		125								Constr	
SS	TR	Usak			400/150		250								Planning	

1. type of project (ohl - overhead line, k - kable, sk - submarin kable, ss - substation, bb - back to back system...)
2. Country (ISO code)
3. Substation name
4. Installed voltage (for lines nominal voltage, for transformers ratio in voltages)
5. number of circuits/units
6. Conventional transmission capacity of elements for OHL in Amps, for transformers in MVA
7. Conventional transmission capacity limited by transformers or substations
8. Type of conductor or transformer (ACSR - Aluminium Crossection Steel Reinforced, or code of conductor, PS - phase shift transformer...)
9. Crossection (number of ropes in bundle x cross section/cross section of reinforcement rope)
10. Length till border of first state
11. Length till border of second state
12. Total length
13. Date of commissioning (estimate)
14. Status of project (Idea, Feasibility study, Construction, Damaged, out of service, Decommissioned...)

USAID Hydropower Investment Promotion Project (USAID-HIPP)

Deloitte Consulting Overseas Projects - HIPP

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